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KEEPING LIVESTOCK HEALTHY

WE welcome the publication by the United States Department of Agriculture of its latest Yearbook entitled "Keeping Livestock Healthy" (1). This is the seventh Yearbook issued by the Department in a series dealing with important aspects of modern agriculture. The first two Yearbooks in the series, published in 1936 and 1937 respectively, under the title "Better Plants and Animals" (2) dealt with the problem of plant and animal breeding. The 1938 Yearbook was devoted to "Soils and Men" (3), the 1939 to "Food and Life" (4), the 1940 to "Farmers and a Changing World" (5), and the 1941 to "Climate and Men" (6). The whole series to date forms a most useful set of references not only for modern American farmers for which it has been designed but also for agricultural research workers and others interested in the various aspects of present day agriculture. Every volume runs into many pages and contains a mass of valuable material both of a technical and non-technical nature—the main object throughout being to sum up the discoveries of scientists and at the same time to point out the imperfectness of our knowledge of the subjects dealt with.

The latest Yearbook is intended to serve as a manual or reference book of animal health and should prove most useful to students of agriculture and technical workers as well as farmers. All those engaged in livestock production are urged to adopt more careful methods of animal husbandry and to apply existing knowledge in order to combat the numerous and varied diseases, insects, and parasites that attack domestic animals. In spite of a never ending war against such diseases and pests it is pointed out that the extent of the losses which they cause in the United States is well over $400,000,000 a year. It is considered that these huge losses could be enormously reduced if all farmers and

N.B.—The Yearbooks of Agriculture issued by the U. S. A. Department may be purchased from the Superintendent of Documents, Washington, D.C.

(1) 1942 Yearbook—pp. 1276—price $1.75
(2) 1936 Yearbook—pp. 1189—price $1.25
1937 Yearbook—pp. 1497—price $2.00
(3) 1938 Yearbook—pp. 1232—price $1.75
(4) 1939 Yearbook—pp. 1165—price $1.50
(5) 1940 Yearbook—pp. 1215—price $1.50
(6) 1941 Yearbook—pp. 1248—price $1.75

others directly concerned with the livestock industry would adopt sound practices in their everyday operations. Great numbers of animals, for example, are unnecessarily lost every year or fail to produce what they should, because management practices that would prevent ordinary diseases and parasites from getting a foothold are not followed on the farm.

Other methods recommended for dealing with the problem of animal diseases include the prosecution of aggressive research in order to discover how to combat livestock enemies, vigilant regulation to prevent the spread of certain diseases and safeguard the public's food supply, and the carrying of extensive campaigns in order to reduce especially dangerous diseases to a minimum. As far as research is concerned there are animal diseases that we cannot fight with full effectiveness until we have more knowledge. "The avian leukosis complex, which includes fowl paralysis, is an example of this group; it accounts for about half the total annual loss due to infectious diseases in poultry. Until research discovers the cause of this disease and the way it spreads, we are groping in the dark in our efforts to control it". Again, through the strict enforcement of regulations it is possible to keep diseases entirely out of a country. Much has also been done by the application of vigorous eradication methods. Many diseases are, for example, under much better control than they were while there is good reason to believe that several will gradually be reduced to a vanishing point. In the case of serious contagious diseases the more thoroughly they are brought under control, the more vigilant we have to be to make sure that they never gain a foothold thereafter. This battle, however, cannot be waged by official agencies alone, it demands the full co-operation of producers and the public.

Attention is drawn in the book to the fact that veterinary medicine is more closely associated with human medicine than most persons realise. "Many of the discoveries of human medicine" it states "are applied by the veterinarian, but the reverse is as often the case; some of the discoveries made in animal-disease research have been of inestimable values in human medicine. The lines cross at many points. To take a single example, the virus that causes sleeping sickness of horses also causes sleeping sickness of human beings, and in its action it is not unlike other viruses that produce a group of dreaded diseases of the brain and spinal cord. The more we can find out about such a disease-producing agent, the better."

A very wide field is covered by the Yearbook. After discussing the fundamentals of disease and insect control and the important general diseases common to several species, it gives very full accounts of the diseases of all classes of livestock—horses and mules, dairy and beef cattle, pigs, sheep and goats and even dogs and cats—the last section of the book being concerned with wild life diseases and parasites. The treatment, when known, of each disease is given. The book is, of course, mainly devoted to animal diseases occurring in the United States and does not discuss some of the very serious tropical diseases of livestock. It nevertheless contains much information that would be of considerable value to veterinary officers and others working with livestock in the tropics and, in this respect, can be safely recommended to them.

RECENT ADVANCES IN THE USE OF INSECTICIDES

One of the main developments of recent years has been the rapid increase in the use of plant products, such as derris and pyrethrum. Both have been available for very many years. Now they can be assayed with some sort of accuracy, though it must be admitted that the chemical assay and the insecticidal properties, as determined by experiment in the field, do not always tally. Two of the most recent developments in pest control practice concern combinations of these products with oils that have long been used for pest control.

Oil sprays are, of course, used widely for the control of citrus pests, but the concentration is often very close to phytocidal limits when good control of the pest is to be obtained. By incorporating derris in the oil, it has been found possible to maintain the kill—and sometimes to increase it—with a much lower concentration of oil than would otherwise be used. To incorporate the derris in the oil is by no means an easy problem, but "solubilizers" have been discovered which overcome this difficulty. This new development suggests a way for the simultaneous control of two different insect pests. In citrus areas in Queensland derris gives a reasonable degree of control of the bronzy orange bug and various oil sprays give reasonable control of the scale insects. A combined spray, properly applied and timed, might well solve the problem.

Pyrethrum-oil sprays are of more interest in connection with the control of some stored product pests. A few years ago, Potter in Great Britain found that the film left on any surface, after the application of a spray containing an ether extract of pyrethrum in an oil of the medicinal paraffin type, continued to be lethal to larvae or moths, which come in contact with it, for a period of some weeks. The spray without any dilution in water is applied through a spray gun motivated by air pressure. The spray is non-tainting and can thus be used in and on products which very readily take up odours.

Storage pests are a source of considerable loss in tropical and sub-tropical countries, and there can be little doubt that sprays of the medicinal paraffin-pyrethrum type will in the future be generally applied in all the larger warehouses and storage depots.—(Abstracted from *Jr. of the Australian Inst. of Agr. Sci.*, VIII, No. 2).

POD SPOT OF OKRA (*HIBISCUS ESCULENTUS* L.) AND A LEAF SPOT OF (*HIBISCUS ROSA-SINENSIS* L.) IN CEYLON

BY

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The two diseases described in this paper occurred in the writer's garden at St. Coombs,* Talawakelle, Ceylon. Both are apparently new to the island (Bertus *in litt.*). The first to be observed was a leaf spot of the common red Hibiscus, *H. rosa-sinensis* L., collected in May, 1941, and attributed at the time to an unidentified species of *Phyllosticta*. A year later, a destructive pod spot of okra (*H. esculentus* L.,—here known as "bandakka", or "lady's fingers") made its appearance. This disease was associated with the pycnidial fungus *Ascochyta abelmoschi* Harter. The affected okra plants were growing within a few yards of a Hibiscus hedge in which the leaf spot disease, noted the previous year, was again present. A re-examination of this disease showed that the associated fungus, hitherto believed to be a *Phyllosticta*, was in fact an *Ascochyta* (having a few two-celled spores) and might be the same as *A. abelmoschi*. Certain differences appear to exist between the fungi on the two hosts, and in the absence of cross inoculation experiments, for which no opportunity is available to the writer, their identity is regarded as provisional. Accordingly, in the present communication, the diseases are dealt with separately.

"Bandakka" is a popular vegetable in Ceylon and elsewhere and the pod spot disease, which is not widely known, merits a short description. Any likelihood of its being associated with a disease of such a common ornamental and hedge plant as *Hibiscus rosa-sinensis* is of obvious economic significance. It is worth noting that neither disease has been found so far on wild plants of *H. primulinus* Alst. growing in the neighbourhood.

1. Pod Spot of Okra— *Ascochyta abelmoschi* Harter

The spots are at first circular but later become somewhat oval to oblong in shape, following the length of the fruit and situated generally in the furrow between two adjacent vascular ridges. The fruit illustrated in fig. 1, was about 10 cms. in length, having two lesions with their centres 2 cms. apart in the middle of one furrow. The two lesions had coalesced and then spread to form a brown, water-soaked area extending nearly the whole length of the fruit and rather more than half the circumference in its widest part. Pycnidia are at first abundant, with more or less zonation following the original shape of the spots. Later they may develop indiscriminately over the entire area of dead, water-soaked tissue. In the later stages of the disease, perhaps assisted by secondary bacterial invasion, the soft tissues become rotted away in the centre of the lesion exposing the fibrous skeleton, and in this region also there may be a slight gummy exudation.

The fungus also penetrates to the interior of the fruit and infects the seeds, forming pycnidia on them in great abundance. The seeds bearing pycnidia appear normally developed, the infection in all probability being confined to the seed coat. In a moist chamber the seeds become covered with minute yellowish masses of spores which are extruded from the pycnidia.

As seen under the microscope, the pycnidia on the fruits are immersed, erumpent, dark brown in colour with a dark and thickened rim around the narrow ostiole. They are crowded and tend to be gregarious, their normally circular or rounded outline in surface view becoming irregularly polygonal when several pycnidia are in contact (fig. 3). The fungal hyphae in the vicinity of the pycnidia are broad and dark, much branched. On the seeds, which are themselves black, both pycnidia and mycelium are darker in colour than they are on the fruits. The measurement of fifty pycnidia gave the following results :—

Diameter of pycnidia :—60-130μ

Mean 102.5$\mu \pm 2.25\mu$**

Diameter of ostiole :— 10-30μ

Mean 19.2$\mu \pm 0.61\mu$

The ripe pycnidia extrude spore tendrils immediately on immersion in water and a fragment of tissue bearing pycnidia soon becomes cottony in appearance from this cause. The process of extrusion may continue for about ten minutes. The tendril is usually sinuous and reaches 3-4 mm. or more in length, with a width of 20-30μ. It is at first quite tenacious and elastic and retains its form in water, if left undisturbed, for half an hour or longer. In moist air, the extrusion is a gradual process and no spore tendril is formed.

The spores (fig. 3) are hyaline, rather variable in shape, oval to oblong or very slightly curved, rounded at the ends, and sometimes guttulate. They are mostly continuous, but with a low percentage (probably not more than 10 per cent. in the samples examined) of two-celled spores, sometimes slightly constricted at the septum. A mixed population of a hundred spores measured in water gave the following dimensions :—

Length :— 4.5—9.5μ Mean 6.5$\mu \pm 0.14\mu$

Breadth :— 2.0—4.0μ Mean 2.8$\mu \pm 0.05\mu$

The occurrence of two-celled spores was confirmed from among those exuded by a single pycnidium. No accurate comparison of the dimensions of one- and two-celled spores was attempted owing to the relative scarcity of the latter. A random selection of ten spores of each type gave the following mean measurements :—

One-celled spores, 5.9$\mu \times 2.7\mu$;

two-celled spores, 7.6$\mu \times 3.1\mu$.

* Elevation 4,500 feet.

**The standard error of the mean is implied by this expression.

Both types of spore germinated within twelve hours in distilled water and in an extract of the "bandakka" fruit tissue.

The fungus was isolated from freshly exuded spores obtained after surface sterilization of pycnidia from the fruits and the seeds. It grew readily with copious aerial mycelium on maltose agar plates and on steamed potato cylinders but formed no pycnidia after one month. On raw aseptic potato slices a brown discoloration was produced around the point of inoculation, with only a very scanty aerial mycelium.

In pycnidial and spore characters, as well as in the symptoms produced on the host plants, the fungus agrees closely with the description of *Ascochyta abelmoschi* Harter which was noted originally (4) from the United States in 1918. In cultural characteristics, the agreement is less close, Harter (*l.c.*) reporting the early production of pycnidia on steamed potato cylinders. Harter's inoculation experiments indicate that the fungus is pathogenic chiefly to young pods and may also be found on the stems, where, however, little damage results. It is not found to affect the leaves.

Very few other references to *Ascochyta abelmoschi* have been found in the literature, and the present distribution of the fungus outside America remains uncertain. Harter, while admitting that the original outbreak described by him might be traceable to domestic sources, also suggests the possibility that the fungus had been introduced with seed imported either from S. Europe (Greece : Caucasus) or from India. A recent record from Bulgaria (7) confirms the presence of the fungus in the former continent : it is not, however, listed in "The Fungi of India" (2, 10). Seed dispersal would appear so feasible that it would be reasonable to expect the fungus to occur wherever the host plant is grown.

Harter (4) gives no recommendations for the control of the disease and nothing appears to be known of the climatic conditions which favour its spread. The outbreak observed by the writer was on a small scale and affected plants which were in any case near the end of their growing season. "Bandakka" does not do particularly well on St. Coombs and it seems likely that the disease would be more serious at lower elevations, where the growth of the pods is more rapid. The disease can evidently develop in storage (15), so that its dispersal after harvest must be reckoned with. In the field, it would probably be controlled by routine spraying and hygienic measures, but extra care would be necessary in raising crops for seed. The twelve or thirteen Ceylon indigenous *Hibiscus* spp. must be viewed with suspicion as possible hosts for the disease. The problem of control would be enormously complicated should the possible connection with the leaf spot disease of *H. rosa-sinensis* be confirmed.

2. Leaf Spot of *Hibiscus rosa-sinensis*

The spots originate either at the margin or in the lamina. They are circular in outline and spread rapidly, the largest spots seen being 1.5 – 2 cms. in diameter. They vary from dark brown to purple in colour and are most conspicuous in the later stages when the leaf is senescent and brightly tinted with yellow and red. Frequently the yellowing and senescence originate in the vicinity of the spot. As the spot increases in size, the centre becomes pale and papery and may eventually be deciduous. The well-marked zonation of the epiphyllous pycnidia is a conspicuous feature (fig. 2).

The appearance of the pycnidia under the microscope is similar to that described above for those associated with the okra pod spot except that the pycnidia are less frequently gregarious and hence are more regularly circular in outline. Their size was estimated in 1941 and again in 1942, on each occasion from a sample of twenty-five viewed *in situ* :—

1941. Diameter of pycnidia :—105-200μ
Mean 153.6μ ±5.66μ
Diameter of ostiole :— 15-40μ
Mean 29.6μ ±1.08μ

1942. Diameter of pycnidia : 80-155μ
Mean 122.0μ ±4.07μ
Diameter of ostiole :— 20-30μ
Mean 22.8μ ·58μ

It will be noted that the 1941 means are significantly greater than the 1942 means : both values for the *H. rosa-sinensis* pycnidia are significantly larger than the mean for the pycnidia of *Ascochyta abelmoschi* on *H. esculentus*.

The spores are quite similar in shape and appearance to those of *A. abelmoschi* but the samples have varied greatly in size from year to year, as will be seen from Table I. The smallest dimensions are those from the 1941 sample, in which year no 2-celled spores were seen. The latter when they occur are slightly larger on the average than the aseptate spores, but their presence alone in the low frequencies observed (not more than 10-12%) is insufficient to account for the increase in spore dimensions noted in 1942 (fig. 4).

Table I

Hibiscus **fungi : spore measurements from samples of fifty, in μ**

H. rosa-sinensis	Means	Limits
(1) 1941 (no 2-celled)	5.9±0.09	(4.5—7.5)
	×2.4±0.04	(2.0—3.0)
(2) 1942 (with 2-celled)	7.0±0.11	(6.0—9.0)
	×2.8±0.06	(2.0—4.5)
(3) 1942, 2nd examination (do.)	8.4±0.14	(5.5—10.5)
	×3.0±0.05	(2.5—4.0)
(Av. of 150 spores :—	7.1×2.7)	
H. esculentus		
(4) 1942, mixed ...	6.6±0.11	(4.5—9.0)
	×2.8±0.07	(2.0—3.5)
(5) 1942, one pycnidium	6.7±0.13	(5.0—9.0)
	×2.8±0.04	(2.0—3.5)

FIG. 1.—" Bandakka " pod with two spots caused by *Ascochyta abelmoschi* Harter (4/5 natural size).

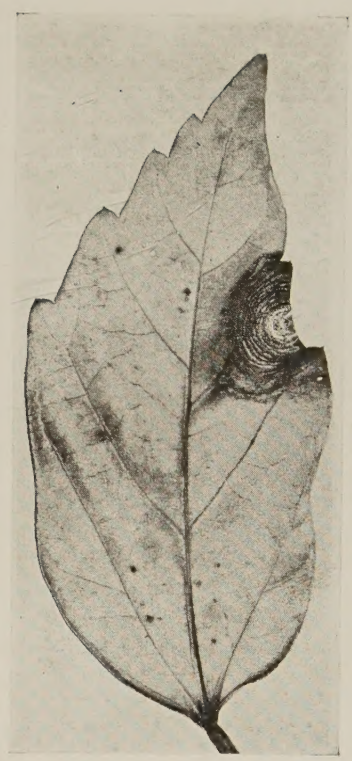

FIG. 2.—Leaf of *Hibiscus rosa-sinensis* with single leaf spot, showing zonate pycnidia (natural size).

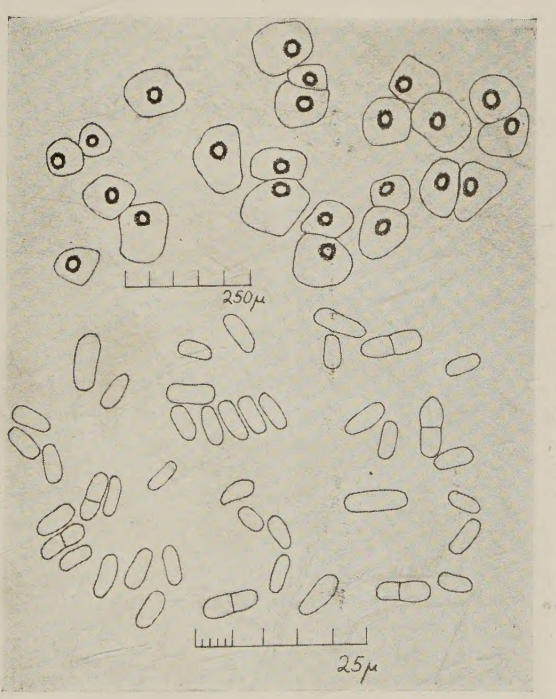

FIG. 3.—*Ascochyta abelmoschi* Harter. *Above*, pycnidia in surface view, *in situ*, × 66; *below*, fresh spores in water, × 900 (camera lucida drawings).

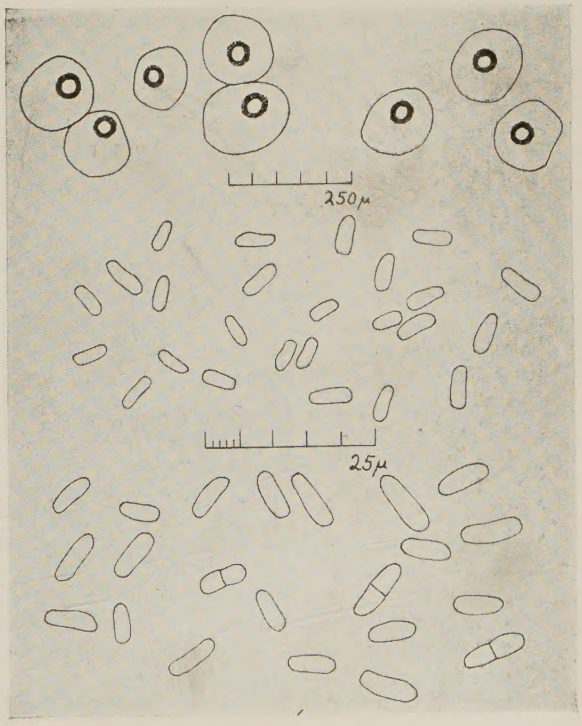

FIG. 4.—*H. rosa-sinensis* fungus. *Above*, pycnidia (1941), *in situ*; *centre*, spores (1941); *below*, spores (1942). (Magnifications, &c., as in fig. 3).

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It has already been stated that the fungus from *H. rosa-sinensis* was identified originally as a *Phyllosticta* sp. but was subsequently treated as an *Ascochyta* sp. on the grounds of the occurrence of two-celled spores. There is of course no guarantee that the 1941 and 1942 collections represent the same fungus, but it seems reasonable to assume that they do so, since the symptoms on both occasions were the same. Two other considerations are relevant and are dealt with in the succeeding paragraphs.

Firstly, there is the known tendency for *Ascochyta* species to produce mostly aseptate spores, which become septate after a long time, or only on germination. Only about 10 per cent. of the spores of *A. abelmoschi* on okra were septate, while Harter (4) also never found more than 50 per cent. septate. Dealing with collections of *Ascochyta imperfecta* Peck, causing the black stem disease of lucerne (*Medicago sativa* L.) in Britain and the United States, Toovey, Waterston, and Brooks (13) state that "the percentage of uniseptate spores in a pycnidium is extremely variable, and in some collections in the field and in certain cultures all the spores were unicellular".

Secondly, it is evident that too much reliance should not be placed on differences in the dimensions only of spores and pycnidia. Toovey *et al.* (*l.c.*) give a whole series of mean measurements based on samples of one hundred spores, many of which are significantly different one from another, yet which are all attributed to the same fungus. Moreover, Harter's range of variability for the spores and pycnidia of *Ascochyta abelmoschi*, 4.0-14.0 × 2.1 — 4.5μ, and 65-225μ in diameter respectively, easily covers all the collections summarised here. Thus, on these grounds, and subject to confirmatory experimental evidence, the leaf spot of *H. rosa-sinensis* may be attributed to *Ascochyta abelmoschi* Harter, with the proviso that on this host the pycnidia appear to be larger, and the spores more variable in size, than they are on *H. esculentus*.

Ascochyta abelmoschi has not so far been recorded from any other host but *Hibiscus* (= *Abelmoschus*) *esculentus*. In attempting to relate the disease of *H. rosa-sinensis* to what has previously been recorded in the literature for these and other *Hibiscus* spp., four genera of imperfect fungi needed consideration. *Phyllosticta* was indicated from the first by the 1941 data. This genus led naturally to the inclusion of *Phoma*. The difficulty in distinguishing between *Phyllosticta* and *Phoma* is met with again in an even more pronounced form as between *Ascochyta* and *Diplodina*. Grove (3), for instance, whose views on the two former genera were summarised recently by the writer (1) and who would be strongly opposed to any suggestion for their fusion, states that "it would be more logical to combine the two genera" (*Ascochyta* and *Diplodina*). The work of Toovey *et al.* (13), referred to above, is a case in point, where the fungus *Ascochyta imperfecta* Peck on lucerne could be related to *Diplodina medicaginis* Oud. (type specimens indistinguishable), to *Phoma medicaginis* Malbr. and Roum. (or at least to N. American cultures identified as such), and, in all probability, to *Phyllosticta medicaginis* (Fuck.) Sacc.

A brief summary follows of the species of these four genera known to occur on *Hibiscus*. The list includes eight *Phoma* spp., three *Phyllosticta* spp., two, or possibly three, *Asochyta* spp. (including *A. abelmoschi*), and one *Diplodina* sp. Apparently, none has been recorded hitherto from either leaves or fruits of *Hibiscus* spp. in Ceylon (Bertus, *l.c.*). Except where otherwise indicated the descriptions are from the diagnoses in Saccardo (11). The arrangement is approximately in chronological order of publication.

Phyllosticta syriaca Sacc. (Saccardo, III, no. 142). From Europe, "on leaves of *H. syriacus*". Maculiform; pycnidia 50μ in diameter, spores 7×3—4μ. Described as quite distinct from the next species.

Phoma macularis Desm. (III, no. 658). France, "dry leaves of *H. syriacus*". Scarcely maculiform; pycnidia 200μ diam., spores 7.5 × 2.5μ.

Phoma ophites Sacc. (III, no. 527) was reported from dead stems of *H. syriacus*, and *Phoma malvacearum* West. (III, no. 729) from the stems of *Althaea* spp., *Malva* sp., and *H. esculentus*. The descriptions are meagre, but both appear to be good *Phoma* spp. and purely saprophytic.

Phoma ochra Cke. (III, no. 726) is an American species reported as the cause of diffuse spotting on the stems of *H. esculentus*; spores 10-12 × 3.5μ, no dimensions given for the pycnidia. Harter (4) attributed at least one previous American collection of this name (as "*P. okra*"), in which a large proportion of the spores were uniseptate, to *Ascochyta abelmoschi*. In Cocke's type material, however, no septate spores were found.

Phyllosticta hibiscina Ell. and Ev. (X, no. 4879) was described originally from N. America as causing broad, deciduous spots on the living leaves of *H. mutabilis*; pycnidia "more or less large", spores 6—8×1.5—2μ. Hopkins (6) recently recorded this species from a leaf spot of *H. esculentus* in S. Rhodesia. Judging from the rather meagre diagnosis, this would appear not unlike the 1941 collection of the *H. rosa-sinensis* fungus, except for the much narrower spores.

Phyllosticta hibisci Peck (X, no. 4880), described originally from living leaves of *H. moscheutus*, in N. America, was later (12) recorded from *H. cannabinus*, in India. It is the only species of the four genera dealt with, occurring on *Hibiscus*, which is noted in "The Fungi of India" (2, 10). It appears to differ from *P. hibiscina* in its smaller pycnidia and spots, and in the larger spores (7.5—10×3—4μ) which are borne on long, sometimes branched, conidiophores.

Phoma labilis Sacc. var. *peduncularis* F. Tassi (XIV, no. 3307) was recorded originally from the "dry peduncles of *H. rosa-sinensis*", in Italy, and later by Kvashnina (8), from the stems of

H. cannabinus, in the Caucasus. Pycnidia large, 250-330μ diam., spores 5-6×2—3μ. Material of this species if available, would be well worth examining.

Diplodina hibisci Hollós (XXII, no. 7052). Hungary (1906), "dead stems of *H. syriacus*"; pycnidia 280-320μ diam., spores 10—14×3.5—4μ. This might be a 2-celled spore form of *Phoma labilis* var., above, or of *Phoma ophites* Sacc. No description of *Phoma hibisci* Hollós, recorded from the same host in 1926 (5), has been available to the writer.

Phoma ibiscicola Gz. Fragoso (XXV, no. 8141). Spain (1917), "dead stems of cultivated *Hibiscus* spp."; pycnidia 60-100μ diam., spores 2.5-3 × 0.7—1μ, much smaller than those of any other species noted.

Phoma sabdariffae Sacc. (XXV, no. 8142), described originally (1913) from "dead stems of *H. sabdariffa*", in the Philippines, was recorded recently by Muller and van Eek (9) as the cause of a leaf spot, sometimes with top blight, of the latter species and of *H. cannabinus*, in Java. The pycnidia are described as densely gregarious, 150-180μ diam., spores 12—14×4—4.5μ. Material of this should be compared with the Indian collections of *Phyllosticta hibisci*, and with the following.

"*Ascochyta* sp.", recorded by Kvashnina (8) on the leaves of *H. cannabinus*, in the Caucasus, is probably identical with *Ascochyta hibisci-cannabini* Tranzschel, Gutner, and Khokhryakoff (14), described from the same host and in the same region a few years later. Tranzschel *et al.* note the formation of spots up to 10 mm. in diameter; pycnidia to 180μ diam., spores at first continuous, later 2-celled, 5-10 × 2.5-4.5μ. The authors reserve a fuller description for a later publication, which, however, has not been seen. This fungus might well be the same as *A. abelmoschi* Harter.

The above list of the known occurrences on *Hibiscus* spp., for the four genera concerned, reveals no outstanding analogy with the leaf spot fungus on *H. rosa-sinensis*. Accordingly, the provisional identification with *Ascochyta abelmoschi* is allowed to stand, as explained above. The list can be regarded as a preliminary to further investigations, if and when facilities for the exchange of type and other material again recur. The group of occurrences most in need of investigation would appear to be represented by *Phyllosticta hibiscina*, especially the S. Rhodesian material on *H. esculentus*, and by *Phyllosticta hibisci*, *Phoma labilis* var., *P. sabdariffae*, and the *Ascochyta* spp. on *H. cannabinus*.

Summary

An account is given of two *Hibiscus* diseases new to Ceylon, *viz.*, a pod spot of okra (*H. esculentus* L., caused by the fungus *Ascochyta abelmoschi* Harter) and a leaf spot of the common red *H. rosa-sinensis* caused by an *Ascochyta* sp. which is in all probability the same fungus but which appears to differ somewhat in the dimensions of its spores and pycnidia. In comparing the leaf spot disease with what has previously been recorded in the literature on species of *Hibiscus*, a complete list of the eight *Phoma* spp., three *Phyllosticta* spp., two, or possibly three, *Ascochyta* spp., and one *Diplodina* sp. known to occur on the genus is made. Brief notes are given on these fungi and suggestions are made for future work on them.

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The Editor is prepared to consider signed articles for publication in *Tropical Agriculture*. Such articles should normally vary between 1,000 to 6,000 words and may be illustrated if desired.

AN EXPERIMENT IN LAND SETTLEMENT*

BY

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In 1924 the Empire Cotton Growing Corporation established a large farm at Daudawa, in Katsina Emirate. The function of the Daudawa farm was to co-operate with the Agricultural Department in the multiplication of improved strains of cotton bred by the Government Agricultural Botanist at Samaru. By 1931 Daudawa was in a position to grow 640 acres of cotton, giving sufficient seed to plant up 6,000 acres.

The whole of the acreage of cotton grown at Daudawa was not, however, entirely grown on the home farm. In order to increase the tonnage of seed produced, and also as an experiment in land settlement, selected men were given small holdings on the perimeter of the estate. These men also grew cotton from the Samaru seed and at harvest sold their seed cotton to the estate. By this means an additional 6 tons of cotton seed (sufficient to plant 700 acres) was produced annually.

In the initial stages the object was to produce as much cotton seed as possible, and it was hoped to maintain fertility by the use of green manuring. It did not take many years to show that under N. Nigerian conditions a rotation of two years of cotton and one of mucuna as a green manure was not maintaining fertility. Both the home farm and the small holdings were rapidly losing fertility. It was therefore decided that farm yard manure must be used to maintain fertility. Cattle were purchased gradually and by 1941 a herd of over two hundred cattle was being kept, sufficient to produce 400 tons of farm yard manure per annum, and sufficient to give a dressing of one ton farm yard manure per acre in alternate years. The efficacy of this small dressing of farm yard manure is shown by the fact that whereas in the years previous to the change-over to farm yard manure the average yield of seed cotton had fallen to as low as 128 lbs. per acre, the average yields in 1939 and 1940 and 1941 were respectively 328,347 and 280 lbs. per acre.

The small holders had originally been given fifteen acre holdings only five acres of which had been cleared, and the remaining ten acres were to be cleared gradually by the occupier. Some of the more progressive of the settlers soon realized the value of cattle as a means of reducing manual labour and naturally wished to obtain them. The Empire Cotton Growing Corporation willingly assisted this desirable development by issuing to them two working bulls and the necessary implements on the lines of the Government mixed farming advances scheme. The scheme however had one unsatisfactory feature in that these farmers were able to plough up their own farms quickly and then hire out their cattle to neighbouring non-cattle owning farmers. The effect of this was that although fertility was being regained on most of the estate, the non-cattle owning settlers were farming increased acreages but were returning nothing to the land, and the general situation on the small holdings was deteriorating. In addition the cattle owning settlers did not pay sufficient attention to manure making, nor to the proper application in the rotation of manure which had been produced. Nevertheless the Empire Cotton Growing Corporation had made a start at land settlement, valuable lessons had been learned and much progress made. It was a genuine contribution to the future development of Northern Nigeria.

In April, 1941 the Empire Cotton Growing Corporation decided to hand over Daudawa to the Nigeria Government. (It still however very generously contributes £1,600 annually for the administration of the Daudawa estate.) Government also took over the settlement scheme and the outstanding debts of the settlers, though actually the latter were transferred to the Katsina Native Administration mixed farming advances account. The application of manure was absolutely necessary to regain fertility, and the settlers were given the option of becoming mixed farmers or of vacating their holding.

To become a Daudawa settler an entrance fee of thirty shillings is required, and an extremely satisfactory part of the scheme is that ordinary labourers who would otherwise be unable to farm, are being turned into responsible settled men of property with a greatly improved standard of living. A casual labourer comes to Daudawa for a few days' work, becomes a regular labourer, and is attracted by the settlement scheme, he then deposits regularly from his wages till he has a credit of thirty shillings, when he is given the opportunity to become a settler. If of suitable character he is then given a cleared fifteen acre holding, a compound consisting of two round houses and a cattle pen, four cattle and a plough. It has cost £22 10*s.* 0*d.* to clear the land, and £2 10*s.* 0*d.* to put up the buildings but this is not debited to the farmer as Government requires the settler to grow eight or nine acres of cotton annually and is thus saved the expense of growing this cotton. On the other hand the farmer must repay the Katsina Native Administration the value of the cattle and implements, and in addition a 5 per cent. annual interest on annual outstanding balances is charged, as an insurance against cattle losses. He has security of tenure for life if he continues to farm satisfactorily.

*Reproduced by courtesy of the Editor of *Farm and Forest*.

Farmers sell to the fund crops (at present cotton and groundnuts only) and fat cattle, and also deposit money; in turn they are issued cattle, implements, spare parts for implements, seed, cash (if in credit) and even clothes made on the estate. In the first year of the scheme Daudawa farmers (of whom there were twenty-nine) deposited £50 in cash, £205 was paid into their accounts from the sale of cotton and £265 from the sale of fat cattle. The use of the fund as a savings bank is particularly popular, and practically every farmer made his credit balance spin out until the 1942 gero (spike millet) was ripe. This, naturally, entails a large amount of book-keeping, for repayments vary from £20 worth of cotton down to a cash payment of sixpence, and issues vary from a plough at £4 to a nut at a penny.

Up to the present the Government has made no charge for the amenities provided. The writer would like to impose an annual fee, in return for which a farmer would receive a certain water supply, repairs to buildings, making of broad base terraces to combat erosion, veterinary attention, dipping facilities, the use of the mixed farming scheme as a ban deposit account, and participation in an insurance scheme against cattle losses. In the future we hope to provide a school and medical clinic as part of the amenities of the estate.

Previous to 1942 a new farmer was given two working cattle and a plough as his working equipment. The main object of this estate was and still is, however, to produce cotton seed and it was felt that it was no use setting up small holders unless fertility could be maintained on their small holdings. On a fifteen acre holding at the very least fifteen tons of farmyard manure should be produced annually, to maintain average fertility and possibly give slightly increased fertility. Two cattle could but seldom would do this, but four cattle, with some stall feeding in the rains when grass is easy to cut, can easily produce fifteen tons per annum and more (this figure is taken from actual experimental results at various N. Nigeria stations). All new farmers therefore are, as stated above, now being issued with four cattle, two ready to work immediately and two three-year olds which will be ready to work in the next year. Cows are also issued on a cash basis, and some farmers who now possess the nucleus of a small herd, can and do manure heavily, and the fertility of their holdings is obviously being improved.

The original loan required to set up one of these farms is now much higher than was formerly considered desirable, in the region of sixteen pounds at present day prices, which are practically double pre-war prices. How is this to be repaid? The settlers only a short time ago were just labourers earning five pence a day. Last year, exact figures were kept of seven fifteen-acre Government holdings each worked entirely by a man and a boy, and the gross return per holding from the sale of crops was £18. A farmer working for himself should produce as much as a man and a boy paid by Government. In addition, at the end of the rains he can sell his working cattle, for his three-year olds will be able to work in the next year and the farmer should make a considerable profit on the transaction.

The following is a specimen balance sheet of what is estimated will be the position of farmers set up in April, 1942, at the end of one season's operation.

Initial Costs						
Two working cattle	...	£7	0	0		
Two small cattle	...	4	0	0		
One plough ...	...	4	10	0		
Insurance fund ...	...		15	0		
					£16	5 0
Two new young cattle ...					4	0 0
Expenses, herding, plough spares, labour picking cotton ...					1	15 0
Profit on year's working ...					13	5 0
					£35	5 0
Sales of Produce						
Eight acres cotton	...	£12	0	0		
Two acres groundnuts	...	2	10	0		
One acre rama	...	1	5	0		
Four acres corn ...	...	7	10	0		
Sale of 2 fat cattle	...	12	0	0		
					£35	5 0

The profit on the first year is roughly equal to the initial costs of stock and equipment. And this can be taken as a rough and ready axiom, for if the prices of farm produce are low the price of cattle and of the plough will be correspondingly reduced. The only danger of loss is when a farmer buys his equipment at times of high prices followed immediately by a slump, but even in this case, the Native Administration should be able to effect rebates, for in the years of rising prices a considerable profit has been made for the mixed farming scheme, which was never intended to be profit making. (Actually £300 6*s*. 8*d*. have been paid in to Native Administration revenue, against which £4 19*s*. 5*d*. has been expended as the result of an embezzlement.) It may be said that a third of the above profit is derived from the sale of fat cattle, a trade which is extremely variable. The estate has this in mind, and if the meat market were not favourable, farmers would be advised to keep their large cattle and use them for road haulage in the dry season, for contracts could be made with the estate and with the Road Engineer, for the collecting and carting of road metal, and for the transport of produce to the railway. This would entail the sale of carts to groups of farmers, but, with the present system of communal marketing and communal banking, this would not present the slightest difficulty.

Economically we believe the scheme to be sound under all ranges of economic conditions, for, even if the worst came to the worst, and there came a time when there was no export market for the products of N. Nigeria, the mixed farmer on a well manured holding would still be in a better position to produce a bigger output of local commodities

than would his hand-farming neighbour. He has taken advantage of most of the innovations suggested by the Agricultural Department, for he has the greatest confidence in our extension workers, who are all expert cattlemen and expert farmers. The farmers have willingly agreed to our advice to stall feed their cattle in the height of the rains in order to avoid disease and increase manure, they take full advantage of the cattle dips and the regular inoculations and clinic facilities provided by the Veterinary Department, and many slight but important alterations in crop cultivations have become routine after one season's trial over a small portion of their farms.

If however our economic and technical problems have largely been overcome, the psychological problem, the Hausa temperament, has still to be successfully tackled. The greatest problem with which we are confronted is undoubtedly the thriftlessness of the Hausa and it is difficult to see how this problem will be circumvented. The following example will illustrate what we are up against. When Government took over the estate there were twenty-nine small holdings, nineteen of the occupiers possessing cattle and ten occupiers farming by hand. The original cattle owning farmers, at the end of the 1941 season, found that if they realised their assets they possessed a considerable sum of money, a fortune in their eyes. For settlers who had been given cleared holdings had been charged clearing costs at the rate of fifteen shillings per acre by the Empire Cotton Growing Corporation. When Government took over it was felt that it was undesirable to have a portion of the farm, on which the settlers were not tenants, and over whom therefore we had no control. These clearing costs were refunded, and this together with the value of their cotton and their cattle and implements, which the Katsina Native Administration re-purchased, caused six settlers to decide to realise their assets and leave the estate, and they departed in each case with upwards of fifteen pounds. If this became a regular practice, it would undoubtedly put an end to the Daudawa settlement scheme and to any future settlement schemes in Hausa country. But it is noteworthy that, owing to the fact that in each case this wealth has been squandered, rather than becoming infectious their example has made the remaining settlers realise the value of their holdings. Their action has certainly not reduced the popularity of the scheme, for the present position is that all the ten hand-farming settlers have become mixed farmers; nineteen new farmers have been given holdings, and we now have forty-two settlers farming six hundred and seventy acres of arable land. Mention has been made above of the use of the scheme as a communal bank. Hundreds of pounds have gradually been doled out to the owners, but had it not been for the influence and persuasive qualities of the officers in charge, the greater part of this sum would undoubtedly have been withdrawn the minute it became available, and yet now, when all our farmers have passed through a long dry season without experiencing hunger or debt, the farmers are full of gratitude that they were dissuaded from embarking on reckless expenditure.

Such a degree of control will not be possible if the number of settlers becomes much larger as the officer in charge will not have time to be philosopher and guide to so many individuals. However all change begins with the few and one can but hope that the example set by the more thrifty settlers will in time influence those of more impecunious temperament; but it is likely to be a slow process as the normal tendency of mankind, the Hausa included, is to spend not as he must but as he can.

The scheme has undoubtedly great possibilities and holds the promise of a greatly improved standard of living for those participating in it. To ensure its success, however, it may be necessary at a later date to institute a properly organised Thrift Society and in such an event the expert advice and assistance of the Co-operative Officer will have to be sought.

SUGAR-CANE WAX

Manufacturer of sugar-cane wax as a by product of the sugar industry has again attracted attention of the Governments of South Africa and the United States. R. T. Balch in America (*Industrial Reference Series Part I, Chemicals and Allied Products, No. 76*, October, 1941—United States Department of Commerce) and about the same time Narasing Rao and Vidyarthi (*Indian Sugar*, 10, 23) report that the dried press-mud-cake contained from 5 to 17 per cent. of wax. Since direct collection would not be economically possible, the American worker has used organic solvents for the extraction of the wax and for the separation of fat from the extracted wax. Toluene has been found to be a convenient solvent for the extraction of the wax from the pressed mud. The removal of the fat is done by cold diffusion using a selective solvent for which acetone is indicated. This method of fat removal has the advantage of the absence of the bad smell, which probably occurs in the putrefactive fermentation method. On the basis of these results, the Sugar Plant Field Station, Houma, Louisiana, intends to set up a pilot plant. The Indian workers observe that the cane-wax corresponds to flax wax and beeswax and contains sterols.

Experiments conducted by K. A. N. Rao and G. N. Gupta at the Imperial Institute of Sugar Technology, Cawnpore (*Proc. 10th Ann. Con. Sugar Tech. Asoc. India*, 79) on the extraction of the wax on a commercial scale have shown that "Solvent Oil" b.p. 75-135°C., obtainable from Messrs. Burmah Shell Co., is both an effective and economical solvent. The wax is recovered in 9.94 per cent. yield and the solvent loss is only 7.5 per cent. The wax compares very favourably with carnauba or beeswax in its properties. Removal of the wax does not in any way affect the properties of the sugar-cane mud for preparation of compost.—(*Current Science*, XI, Nos. 9 and 11, 1942.)

CHEMISTRY AND AGRICULTURAL RECONSTRUCTION*

BY

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The Food Production Problem

One of the hard lessons the war has taught us is that the easy, happy-go-lucky methods of democracy, however pleasing they may be for the participants, are no match for the carefully planned methods of an autocracy. And while we shall always be quite unwilling to give up our freedom and our democracy we are realising more and more that some degree of planning must be grafted on to it. The resultant system will no doubt be even more illogical than the present one, but fortunately the great British public has a healthy disregard for logical simplicity in either private or public life, and, once the need for planning is recognised, the methods will be evolved. This necessity for some plan is particularly urgent for agriculture . . .

No official post-war policy in agriculture has yet been announced, but we shall assume that there will be one and that it will aim at increasing the total output; this will necessitate the decision as to what form the increase shall take. Is it to be an all-round increase on the different items of pre-war production, or developments in specific directions? The all-round increase could be left to the discretion of individual farmers and induced and sustained by various financial devices. On the other hand, developments in specific directions would involve some degree of planning, and of long-term arrangements with overseas producers in the Empire and out of it as to what quantities of foodstuffs we should be likely to require from them in view of the amounts that we expected to produce ourselves. This procedure would allow of much fuller use of science than at present, and would permit of agreed and satisfactory prices being paid to our own farmers, to be smoothed out, however, by assimilation with the price paid for the imported portion. Judging from the discussions now going on, the balance of opinion seems to be in favour of some large-scale planning and organization in our agriculture and I shall assume that this will occur, and discuss the part the chemist may be expected to play in it. As the past is the surest guide to the future, I shall begin by setting out something of what he has done and particularly of how he has done it.

The Achievements of the Chemist

(*a*) *The empirical period.*—It is extremely gratifying to record that chemists have been able to achieve a highly respectable total of successes in agriculture. The foundation work was done from 1829 onwards by Boussingault on his farm at Bechelbronn, Alsace, who used analytical chemistry to make up balance sheets showing what the various crops took out from the soil. Practical application began rather more than a hundred years ago, when Liebig applied his profound knowledge of chemistry to agriculture of which he knew very little, and on *a priori* grounds and without making any experiments arrived at certain conclusions of far-reaching importance. At the same period Lawes at Rothamsted applied a slender knowledge of chemistry with much shrewdness to agriculture, for which he had a profound and sound feeling, but did it experimentally and without any *a priori* procedure. Both methods were used in the nineteenth century; distinguished scientists and others applied *a priori* reasoning to agricultural problems and arrived at certain conclusions; and another group, less distinguished and not so well furnished with chemical knowledge, made experiments liks those of Lawes and were able to show definite results. The experimental method won, and its great triumph was the establishment and development of the artificial fertilizer industry, which proved so valuable to agriculture that before the war some forty million tons were being used annually by farmers.

Common honesty compels us to admit that there was very little chemistry at the foundation of the industry; the whole procedure was almost entirely empirical. Lawes' note-book is really rather a shocking affair and would certainly have earned him a reprimand from any conscientious professor of chemistry. The early field experiments at Rothamsted seem to us entirely haphazard; it was nearly ten years before Lawes and Gilbert pulled the whole lot together in 1852 and put them on the coherent basis which has been maintained ever since. It is rather chastening to reflect that most of the big advances in agricultural practice have been empirical and that frequently the scientist only came in later to prove what by that time every farmer knew.

Like many of the men of the nineteenth century Lawes and Gilbert had little use for theory. Their early scientific work had been the drastic criticism of Liebig's so-called "mineral theory," according to which plants took their carbon, nitrogen, oxygen, and hydrogen from the air, and only their mineral constituents from the soil; these alone, therefore, needed to be supplied in the manure. Lawes and Gilbert showed that this was wrong, that nitrogen must also be given, indeed that the yield generally rose and fell in proportion to the amount of nitrogen supplied. Of all the agricultural work in the nineteenth

* Messel Lecture delivered before the Society of Chemical Industry and reprinted from *Chemistry and Industry*, Vol. 61, No. 30. The introductory remarks which include references to agricultural production in England and Wales have been omitted.

century in Great Britain theirs was the most scientific and its purpose was to obtain knowledge, but the aim was purely utilitarian; there was no talk of Science for Science's sake, simply and solely what use could be made of it. "The object of these experiments," said Lawes, in speaking to farmers, "is not to put money into my pocket, but to give you the knowledge that will help you put money into yours."

This purely utilitarian purpose dominated the work of the agricultural chemists of the nineteenth century. Its effect was to make their work almost entirely analytical. They had analyzed crops, soils, fertilizers, feeding stuffs, in short all the raw materials and all the final products of the farm: they made field trials and feeding tests and set out the results concisely and systematically. Even today little could be added to some of the recommendations made by such shrewd experts as Augustus Voelcker seventy or eighty years ago. The best summary of the old work is Robert Warington's "Chemistry of the Farm": a short treatise covering the whole range of agriculture because it simply dealt with analytical data.

(*b*) *The scientific period.*—A fundamental change came in 1888, when the Government, alarmed at the persistent and growing depression in agriculture, decided to provide technical instruction in agriculture. As usual in those days, the scheme was tentative, permissive, and very slow in operation; counties that "didn't hold with education" need not have it, but the more advanced counties gradually set up agricultural schools or colleges, and some of the more enterprising Universities started Agricultural Departments. The machinery of agricultural education began to function and this necessitated the preparation of systematic courses of lectures and of students' text books. So arose the need for developing definite subjects that could be taught. The old analytical approach was no longer adequate. It was necessary to know not only what the raw materials were composed of, in terms of the old anlaytical chemistry, but what they did, and how they interacted to give the final product. Students had to be taught not only what was, but why it was so. The soil, the plant, and the animal had to be studied as natural objects and not merely as contributors to successful agriculture. It was obviously impossible for one person to be an expert on all these subjects and so the more vigorous-minded younger workers began to specialise and made no attempt to deal with all branches of agriculture, as their seniors had had to do. Some, indeed, went so far as to think that satisfactory progress could be made only by cutting the connexion with agriculture altogether, and setting up new sciences—soil science, plant nutrition, plant pathology, animal nutrition, dairy science, etc., quite independent of agriculture. The method finally adopted was as usual a compromise; the new sciences were developed, the new workers became specialists, each sticking to one subject, but the connexion with agriculture was retained. The new subjects have not all got satisfactory names yet, and we seem to lack the literary inventiveness of the nineteenth century pioneers of science. My own subject, soil science, is an example; we could not ourselves think of a name; at first we followed the Continent and tried "Pedology" only to find that the Americans used the word to mean "children's education" and that some of our own people thought it had to do with walking tours: as when at a British Association meeting a "Pedological excursion" was announced and a certain number of people turned up clad for what was then call "hiking." The net result was that the subject "Agricultural Chemistry" gradually disappeared and persists only in examination syllabuses and the titles of a few professorships; in future, these will have to go to an analyst if the ancient meaning and scope are intended, or to a specialist in one of the new subjects if work of real scientific importance and effective training of students are desired.

The change became much more effective in 1911 as the result of the Development Fund set up by Mr. Lloyd George. This provided for the establishment of research institutes which were allotted to the different Universities and other foundations, including Rothamsted, East Malling, Long Ashton, the Rowett Institute, Macaulay Institute, Hannah Institute, and others, and at the larger of these the purpose was to be long-range research; the gaining of knowledge not for immediate use, but for the winning of further knowledge. It was a complete break-away from the nineteenth century utilitarianism. The functions of the new Institutes were defined as "the extension of knowledge, the study of different sections of agricultural science without reference to the needs of particular localities. The work of the research laboratory must, as a rule, reach the farmer through the college lecturer or local instructor."* The research institutes were to pass their results on to the colleges, who passed them on to the County instructors, who passed them on to the farmers. Conversely any problems or difficulties met with by the County instructors were to be sent up via the colleges to the research institutes. This part of the scheme never worked, and had they kept to the original plan the research institutes would soon have been cut off from contact with agricultural practice, which of course would have been bad for them. But the institutes got round the difficulty, each in its own way.

An ingenious method of financing was adopted. The station submitted a programme of investigation and an estimate of cost. If these were accepted a "Grant-in-Aid" was given, sufficient to cover most of the estimated expenditure, and the Station was left free to raise the balance of money in any way it pleased. Help towards approved capital expenditure was also given,

*Cd. 7179, 1913.

but the rest had to be provided. At Rothamsted we set up for this purpose of raising funds an independent organization, the Society for extending the Rothamsted Experiments. The method worked satisfactorily; the expenditure on capital account at Rothamsted during the period 1912-1941 exceeded £200,000 while the total annual income rose from £5,500 to nearly £46,000. Abundant and excellent scientific work was produced; indeed the British agricultural research stations deservedly enjoy a very high reputation all over the world.

The Results Achieved

The successful development of agricultural science meant that a sound system of agricultural education could be built up, and by common consent ours has been very effective. There is still a time lag between the gaining of new knowledge and its introduction into lecture courses, which however could be reduced by the revival of the practice whereby research workers were invited to give short courses of lectures at a University on their special subjects.

Numerous direct applications of science to farming problems have been made, of which only a few need be mentioned: the marked improvement in the use of fertilizers and feeding stuffs, the widespread recognition of the need for adequate quantities of mineral substances in the ration, the remarkable changes in milk production shown by the "clean milk" campaign, all resulted direct from the efforts of the scientific workers. Other scientific successes are inoculation of leguminous crops, the making of compost, seed treatment with "mercurials" and other fine chemicals to protect against certain fungous diseases, improvements in sprays for fruit trees, selection of stocks for fruit trees, diagnosis and cure of a whole group of plant and animal diseases caused by deficiencies of so-called "minor" elements of nutrition. The list is impressive and although the benefits cannot be expressed in money terms they exceed many times the whole expenditure on research. To take one item only; the farmers of the United Kingdom before the war spent some £6 million annually on artificial fertilizers and in addition made some 12 to 18 million tons of farmyard manure; putting this at 7s. per ton the total expenditure on manures and fertilizers is some £10-12 million annually. Expenditure on lime, on feeding stuffs, and on implements greatly increases this amount, and the aggregate outgoings are very considerable, yet the entire annual expenditure on the research and advisory services including much of the education is less than £500,000.

Still it must be admitted that agricultural chemistry has never been able to repeat its first great triumph or to do anything quite as revolutionary and far reaching as the artificial fertilizer industry proved to be. It sounds paradoxical but there is an element of truth in the statement, that while agricultural science was undeveloped its applications to practice were very successful; but the applications to practice have not kept pace with the remarkable developments of agricultural science that have taken place in recent years.

The Difficulties of Applying Science to Agriculture

(*a*) *Natural difficulties.*—The chemist can hardly be expected to obtain in agriculture the impressing triumphs he has secured in industry. The reason is simple; in industry all processes and agencies are completely under control; a machine can be made as big as one likes and output can be pushed up to astronomical dimensions; how to dispose of the goods at the end is of course another matter which, however, has nothing to do with the chemist. But in agriculture neither the processes nor the agencies are under very much control. In spite of a century of efforts grains of wheat still remain much as they were; there is not the slightest indication that we could ever hope to get them as big as apples, or that bullocks could be made to grow as big as elephants or as little as sheep. The situation might change if some glandular excretion should be discovered that would cause gigantism in animals, and we certainly cannot deny the possibility, but nothing of the kind is within sight and so for the present we must accept existing limitations of size, or something near them. So with the time and rate of reproduction. Each crop takes a certain time to complete its life cycle from seed to finished plant, and though for some varieties the period is shorter than others it is generally true that one cannot artificially shorten the period to any great extent. When this is done by crossing with a shorter period variety, which is the most promising method, there is not infrequently a fall in the yield, which, however, may be more than balanced by reduction of losses incurred in the latter period of growth. Further, the times of seeding and of harvest cannot be much changed; there is some latitude, but in the main, the calendar of operations is out of our hands. Devices such as boxing of potatoes or vernalization of grain may enable sowing to be later, but the biggest change within sight is that autumn varieties might be sown in spring. In regard to animals, there is no indication that either times of oestrum or gestation can be effectively controlled.

Finally the seasons perpetually elude all attempts at control and even at forecasting. In continental regions there are more regularities than here, but our insular climate is beyond present hope, and while a good meteorologist can give a reasonable forecast for a few days he leaves the longer periods to Old Moore and his associates. However, all hope need not be abandoned. At our various experiment stations and particularly at Rothamsted there are great accumulations of data showing how the different

crops grown in various ways have reacted to seasonal conditions. It seems possible to hope for forecasts on the lines that, if the rainfall in the various months deviates to a given extent from the normal, the crop yield will probably deviate to a stated extent from the average. There is the complication, which may present an insuperable difficulty, that the complex of meteorological facts determining plant growth is not sufficiently represented by any single factor such as rainfall to make such a forecast possible. If, however, this could be done, it would open the way to insurance for crop yield on the condition that the farmer had taken certain agreed steps. But it must be admitted that this is not in sight as yet.

Certain psychological difficulties are always operative. Some agriculturists share the usual British distrust of science, much preferring the empirical method and making a sharp distinction between a result demonstrated by an experiment, and one which they claim from experience to be true although they cannot point to any proof. Others have adopted some of the mystical ideas now current, perhaps as a reaction against the materialism of the age, involving vitalism, astrology, lunar influence, and other ideas too elusive to be submitted to any experimental test, but accepted on purely subjective grounds.

(*b*) *Difficulties removable by administrative action.*—The application of science to agriculture presents certain difficulties which might be overcome or at least mitigated by central administrative action. One set of troubles arises from the intense specialization which has become a characteristic of modern science. The first workers at the research stations came from the agricultural advisory and teaching services and consequently had a working knowledge of agriculture derived from direct contact with farmers and efforts to help them on their own farms; their science was not usually of a high order but they achieved such pioneering success that when the Corn Production Act was repealed in 1926 the farmers of the country through their Union asked the Government to devote £1 million to agricultural research. This meant a great expansion of staff of the research institutes and the new workers came and continue to come straight from the Universities as specialists; they usually are from town secondary schools and have a good knowledge of their subject but know nothing of agriculture or even of country life.

This course has become necessary because the agricultural colleges cannot be expected to give specialized scientific training. Then comes the problem of building up the requisite background of agricultural knowledge; this has proved difficult in practice.

The great degree of specialization reacts on the work itself. The initial problem may be fairly simple and its relation to other branches of science readily perceived. But as the work goes on it necessarily becomes narrower and unless special care is taken the worker tends to lose touch with others and even with the pure science from which he had started; so that a specialist in 1942 may be basing his efforts on the pure science of 1922 or even 1912. This intense specialization and resultant losing of touch lies at the root of some of our troubles to-day. Specialists often complain that they are not properly appreciated and talk much of the "frustration of science." Much of the trouble arises from the specialist's difficulty in explaining his purpose and his results. It is not his fault; he has frequently specialized from his childhood upwards and acquired little general education or knowledge of English or of the art of exposition. The schools blame the Universities, the Universities declare themselves helpless, and the trouble will continue until one of them takes a firm stand and refuses to give an honours degree to an arts student who knows nothing about science, or to a science student who lacks a decent knowledge of English and of another language.

Another great difficulty is the rapid senescence of the research faculty. If we may judge by the testimonials of professors and the large numbers of Ph.D's and D.Sc's turned out by our universities, the research faculty is fairly widespread among young people. But only the exceptionally gifted retain it for long. It is most unusual for a man to strike a new line of work after the age of fifty and for many the curtain falls sooner. This does not mean, of course, that they cannot do useful work; they may go on developing theses that they had started in their creative period and may obtain valuable results right to the end of their lives. But only the very gifted can go on evolving new ideas and applying to their development the rich experience gained by years of labour.

Closely allied to this trouble is the weariness that sometimes comes on a man before his work is finished, so that it is not completed or written up properly for publication; it is either filed away for a later effort (which is rarely made) or published very incompletely in some Congress proceedings to secure priority. Considerable sums of public money spent on research never yield their full value because of this failure to complete and publish it. These difficulties are more pronounced at a research institute than in a university, where numerous teaching and administrative duties afford scope for those qualities of judgment and experience which ripen and mellow as the creative research faculty recedes. But they affect all research, and several ways can be suggested for meeting them. One is to ensure a constant succession of young people straight from the degree course, and therefore primed with the most recent knowledge, put them on to some of the problems and see what comes of it. They at any rate will bring in new ideas and new methods—and these are, of course, the breadth of life to research stations. In my view, the best method of overcoming the various difficulties is to facilitate

and encourage movement from one service to another; particularly from research to advisory, and from Empire to home service, and *vice versa*. At Rothamsted we owe a good deal to men who came to us from the Dominions, India, and the Colonies and our men who have gone out have greatly developed as a result.

Looking back one can now see that the application of science to practical farming problems would have gone further had the research service from the outset been more closely linked up with the advisory service and with the Soil Survey. The research officer would have been periodically projected into a wider field and gained new experience, and the adviser would have had the intellectual stimulus of a constant succession of new ideas, useful and otherwise, that he could either assimilate or abandon. Staleness, the *bête noire* of the research station, could have been minimised. These difficulties are not insuperable, and at Rothamsted we claim to have largely overcome them by various devices for keeping all sections of the work in touch, and by maintaining close contact with the problems of the farmer and the agricultural manufacturer.

Administrative Changes

A new administrative body has now been set up, the Agricultural Research Council, on the lines of the Medical Research Council and the Department of Scientific and Industrial Research, and it may be expected that this will exercise much closer control of the institutes than has existed in the past. Time alone can show how far central organization of research is effective. The greatest discoveries of the past have been achieved where the scientific worker has had complete freedom, sometimes even in the face of high expert opinion; it would be easy to compile a list of investigations turned down on *a priori* grounds by an expert committee, but which nevertheless proved very fruitful; conversely, subjects favoured by experts have often given little or no result. This is only another way of saying that experts are after all human and liable to errors in judgment. Obviously public money cannot be squandered on freak investigations, but it is essential to encourage the enthusiasm that overcomes all obstacles and achieves success in face of apparently insuperable difficulties, and to retain the liberty which alone can ensure the constant advancement of science.

Difficulties not confined to Agriculture

This disparity between successful pursuit of pure science and the failure to make use of the knowledge thus gained is not peculiar to agriculture; it appears also in other branches of our national life, especially in Governmental activities. British pure science is at least as good as any other and certainly better than the pure science of Nazi Germany. Yet one regularly hears the complaint that our use of science by Government Departments for the war lags behind that of the Germans; that our designs and inventions are inferior, also that we fail to work out new ideas of strategy and new tactical combinations. I do not set up as a military expert, and I offer no opinion, but at least one can say that in science as applied to the war we do not possess the same lead as we have in pure science. Wherein lies the fault? Do we specialize too much and so lose inventiveness and resourcefulness? Is pure science getting into realms of unreality and so working towards its own undoing, like the philosophy of the Schoolmen in the Middle Ages? Obviously we must find some solution to this problem.

In one direction the application of science to practice proceeds much more successfully. Some of the large industrial concerns have highly efficient research organizations for the solution of their problems; one need mention only Imperial Chemical Industries, Burroughs Wellcome, Boots, Lyons, the General Electric; but there are many others. These organizations have many successes to their credit and the reason, I think, is the very intimate link between the research department and the producing units—much closer than has been achieved in the loose-knit organization of agricultural research. We can, I am sure, learn a great deal from the large industrial research organizations and it would be good to see them represented on the central councils that now regulate State-supported research.

Agricultural Science and its Applications in the Reconstruction Period

It would be futile to attempt any forecast of the developments of agricultural science in the reconstruction period. Certain fundamental problems remain over from the work of this generation and will no doubt be continued by the next: the synthesis of protein from gaseous nitrogen by bacteria and from nitrate by plants; the relations and interactions of the soil micro-organisms in the soil, as distinct from their behaviour in artificial media; soil structure; the chemical constitution of clay and of humus; the chemical phenomena involved in the relations of parasite and host plant—and a host of others.

It is more profitable to try and forecast the directions in which science is likely to find further application in practice. This will be easier when an agricultural policy is announced; for the moment we shall assume a permanent policy of increased production which in view of probable overseas trading arrangements will be largely concerned with products not easily imported such as milk, eggs, vegetables, fruit, and with certain high quality products: meat, barley, and others. A successful and attractive agriculture could be developed on these lines to which science could render considerable service.

Help from biochemistry.—Much use can be made of the new recruit biochemistry—the significance of which in another field was recently

emphasized by the appointment of Prof. C. H. Harington as Director of the National Institute for Medical Research. The old "ultimate analysis" proved very helpful in the past; we can look forward with considerable hope to the results of modern biochemical analysis. L. R. Bishop's work on the proteins of barley grain opened a completely new approach to the problems of barley growing and malting and N. W. Pirie's work on the proteins of green leaves is full of promise for the study of the plant in health and disease. If agriculture is developed on the lines indicated there will obviously be need for close co-operation between the agricultural chemists and the chemists concerned with the utilization of the agricultural products—co-operation which has hitherto been lacking but which we hope will be facilitated by the new Agricultural Group now established by the Society. Hitherto the agricultural chemist has had little or no guidance from the consumer as to what was wanted and he had to accept market price as a measure of quality. We have spent a good deal of time at Rothamsted in trying to find some chemical basis for the differences in market value—sometimes very great—between one sample and another of the same product. Two interesting general rules have come out; they are not of course absolute laws. (1) Excess of nitrogen above that usually present in normal healthy samples of a crop favours attack of certain diseases and lowers the quality of the product; (2) the best quality is usually obtained when the fullest normal crop is grown. So far this is all the guidance the agriculturist has. Excess of nitrogen can be avoided by various agricultural devices such as ensuring a proper balance between the nitrogen and the potash supplied to the crop. Full normal healthy growth is of course a standard subject of investigation in agricultural research institutes. But like other general rules, these suffer from over-simplification, and before further progress can be made we want a clearer definition from the consumer's end of what exactly is required. Once the problem can be expressed in chemical terms it can be fully investigated by the agriculturist; it would for instance be entirely practicable to trace the effect of field conditions on vitamin content of the crop. It is safe to forecast a good deal of co-operative work of this kind in the future.

Similar investigations are needed on fodder crops. At present we can with considerable certainty push up the yield of starch equivalent per acre, but at higher levels of nitrogen content the different constituents are not in the same proportion as at the lower levels, and it is important to discover how this change in proportion affects the nutritive value of the crop and its reaction to disease. This question of quality is of special importance in crops grown for industrial or technical purposes. For sugar beet the chemical problems are simple, but for tea and coffee more difficult; for insecticidal plants they are probably most difficult of all because the buyer has not got the alternative method of the taster's report. According to Sir Harold Hartley about 88 per cent. of the world's agricultural production (reckoned on the basis of value) was before the war used as food; 8 per cent. was used as textiles and 4 per cent. in other industries, where, however, it formed about one-third of the total raw material. There seems to be a growing tendency to look to agriculture for more of these materials. Better industrial utilization of straw and potatoes is very desirable.

Plant nutrition problems.—Another group of problems closely related to these centres round the nutrition of the crop. This of course lies at the basis of all agricultural improvement, for as the old saying goes;

> Bigger crops, more animals,
> More animals, more manure,
> More manure, bigger crops,

and so the improvement goes on in an ascending spiral. I have already stated that the discovery of artificial fertilizers was the first great triumph of chemistry in agriculture; it was achieved about 100 years ago. No new fertilizers have been discovered since the list was completed in the 1860's excepting only basic slag, which was added about 1880. But there have been great technical improvements in the manufacture, and the modern fertilizers are far more easy to handle and to apply than the old materials were. In the post-war period further improvements both in manufacture and in use seem probable.

The need for great economy of production will compel a closer adjustment of fertilizer recipes to crop requirements and soil deficiencies. These are best discovered by systematic and extensive field trials either by associations of farmers like the German "Versuchsringe," or at trial centres like those of the National Institute of Agricultural Botany; but they must be closely linked with detailed chemical examination both of crop and of soil, and with the Soil Survey. The chemist's part will be to improve the methods of soil and crop analysis so that he can with reasonable accuracy forecast the results. Another more difficult problem is concerned with the recovery of fertilizer elements by the crop from the soil. Under present good practice not more than about 50 per cent. of the nitrogen supplied in the manure is recovered in the crop and not usually more than about 25 per cent. of the phosphate, often indeed less. The loss of nitrogen matters less than it seems because fixation from the air is now so well done, but the low recovery of the phosphate is serious because most of our phosphate has to be imported and in any case the world's stocks are limited.

Much more work is required on the elements needed in minute quantities only for plant growth, and indeed likely to be harmful if supplied in larger amounts than required. Already some

six or seven are known and the list is probably not complete. The pioneering work was done by Mazé and by G. Bertrand of the Pasteur Institute, Paris; manganese and iron were found by straight scientific investigation; boron and zinc rather by accident, and copper empirically. Efforts to protect broad beans against the aphis by feeding them with a variety of salts likely to make them distasteful to the insects were unsuccessful in their direct object, but showed that borax increased the growth of beans and this observation, followed up by K. Warington, proved the necessity of small quantities of boron for plant growth. Erratic results of a copper spray intended to deal with a disease of the tung tree led to the successive conclusions that (1) success resulted when the spray was kept in small containers, but not when it was kept in large ones; (2) that the large containers were of wood and the small ones of galvanised iron; and (3) that the curative agent was the small quantity of zinc dissolved out of the container. Further work showed that zinc is essential for a large number of plants.

In this country boron deficiency has been observed chiefly in sugar beet, potatoes, and swedes; and manganese deficiency in potatoes, sugar beet, and oats, especially when grown on light soils rich in lime and organic matter. No clear case of copper deficiency is known, though its occurrence on reclaimed peat soils in Holland and North-West Germany indicates that we may expect to find it here. Nor is there any clear case of zinc deficiency here. Magnesium is in an intervening position; it is required in larger quantities than these elements, but it is usually adequately supplied by the soil, otherwise the crop suffers. Certain unexpected elements are detrimental to the crop or to its feeding value; the harmful effects of "teart" herbage of some of the Lower Lias pastures is attributed to molybdenum; and in parts of the United States though not yet here, selenium occurs in the herbage and injures the animals. One disadvantage of divorcing the soil survey from soil research was that problems of special infertility or of special fertility have not come under investigation as they should have done.

From the outset agricultural chemists were confronted with the view widely held by good farmers that artificial fertilizers were only stimulants; that their continued use would ruin the soil and the crop, and that the only permanently successful manure is farmyard manure. Whatever chemists do about it, this question seems likely to arise perennially. Usually some mystical element is involved; some cycle of death-earth-air-life, involving as an essential feature the use of farmyard manure but not artificials, for which no scientific test is possible. The Rothamsted experiments have shown that for wheat and barley farmyard manure is certainly not necessary; crops grown with artificials only for 99 years, and without any farmyard manure for 103 years, are at least as big as ever and show no signs of falling off. But for potatoes mangolds, and sugar beets the results appear to be different; artificials do not usually give as high yields as a combination of artificials with farmyard manure. The difficulty of exact comparison lies in the fact that, to be of much use, the dressing of farmyard manure must be about 10 tons per acre containing about 150 lb. nitrogen or more, while the dressing of artificials to be of any practical importance must not contain more than about 35 or 40 lb. of nitrogen. Comparative experiments indicate that the nitrogen in farmyard manure has about one-third or one half the value of that in sulphate of ammonia or nitrate of soda; as plant foods the constituents of farmyard manure are inferior to the artificials but the farmyard manure has effects on the soil which artificials do not, and it is presumably these effects that prove so beneficial to potatoes, sugar beet, and mangolds.

Of course it is possible that farmyard manure has some special effects on plant growth. We still have much to learn about the effects of organic substances on plant growth. Wendt and his colleagues at Utrecht showed the remarkable effects of plant hormones: β indolyl acetic acid, β indolyl butyric acid, α napthylacetic acid have been tested in horticulture to stimulate the rooting of cuttings; actions of this kind have as yet found no place in agriculture but they may in the future. Each advance in science has shown the need for greater breadth of view in studying the growth of crops. To the older chemists this was simply a case of supply of nitrogen, potash, phosphate, and lime; later it was seen to be dependent on the whole complex of soil conditions which must be studied before adequate control was possible. The problem is not confined to one generation of plants; crop production has to be regarded as a continuing process, intimately related to the conservation of soil structure and of soil fertility. In recent years there have been tragic examples of soil destruction effected by crop production methods which at the time were profitable but which led direct to drastic soil erosion. The tragedy was intensified by the circumstances that the crop—usually wheat—was often not wanted, and only served to glut the markets, ruining farmers in other countries; in the end much of it was burnt.

The older agricultural chemists recognized the value of organic matter in the soil and accepted the very favourable verdict of practical farmers on this subject. But the term "organic matter" is extremely vague and we have not got very far in making it clearer. We know that the fine rootlets of growing grass are among the best forms of organic matter both for building up soil structure and for supplying plant food; this is perhaps partly due to their widespread ramification in the soil which brings about effective distribution, and partly to the fact that they contain the two basic constituents of soil humus

lignin and protein. Another excellent source of organic matter containing the same two constituents but not so easily distributed in the soil, is farmyard manure. But there is still the demand for more, and so the trade in the so-called "organics" has arisen, so far almost without chemical control as adequate standards hardly exists as yet. In a general way one can say that the percentage of nitrogen in the dry matter of an organic manure should not be less than 2 or 3, and that a good proportion of it should be nitrifiable; but much more detailed specification is desirable. One of the great problems of the future is the agricultural utilization of the wastes of industry and of national life, sewage sludges, town refuse, and the like.

I have left to the last a problem which will grow in importance as the years go by. Mankind is using up at a colossal rate the considerable but definitely limited stores of energy accumulated in past geological ages on this earth. Oil and coal are being consumed as rapidly as we can remove them from the earth, and every kind of ingenuity is displayed in devising new methods for more rapid extraction and destruction. Our descendants will have good cause to stigmatize this age as the most devasting the world has ever known and no doubt will regret that they can only curse us and nothing more. But there is still one source of energy available at present which is hardly stored for light or heat: the sun's radiant energy. The green plant has the power of fixing and storing the sun's energy. The process is not very efficient from the engineering standpoint, less than half of 1 per cent. of the energy received being actually stored. But the amount is capable of being increased, and when the supply of energy becomes a problem this possibility will assume real importance.

It seems clear that the application of science to agriculture in the future will be on a wider basis than in the past. It will no longer suffice, simply to know how a particular nutrient or treatment affects the yield; the effect on composition must be studied, and on the intrinsic and the market values of the crop and its reaction to disease organisms. Like everyone else the chemist must specialize, and so he cannot be expected to become expert in a number of different sciences. But he must cultivate the art of working with other people. As the years go by this need will become more insistent, and success will go to those who have the gifts of co-ordinating the efforts of different scientific workers and of synthesizing into a coherent pattern the multitudinous fragments of truth that they succeed in finding.

PLANT RESISTANCE TO PESTS*

Recent literature on plant breeding, not least in the breeding of the sugar cane, abounds with references to varietal resistance to pests and diseases. In the case of many diseases, in fact, the raising of resistant varieties alone offers grounds for anticipating adequate control. In such cases the thought naturally arises, to what is this resistance due? Is it possible to identify some peculiarity in the resistant variety to which the capacity to resist may be attributed? And, if so, does that peculiarity constitute a character which is inherited? Perhaps, because the breeding of agricultural crop plants has a severely practical object and it is sufficient to know that a certain variety is resistant and can hand on its resistance to its progeny, the basis of that resistance has been less studied than might have been anticipated. Nevertheless, many references may be traced in the literature to the nature of the character or characters responsible and a review of those relating to resistance to pests has recently appeared.† This review covers no less than 567 references and there can be little doubt that a review of the literature dealing with resistance to diseases would be far more extensive. It is to be hoped that some bold person will have the courage to summarize that subject also.

The word "pest" is a non-technical one which has come to be used in technical literature carrying with it a lack of definition which may lead to confusion. In common speech it is of wide application, being as appropriately used to designate the club bore as the domestic flea. In agricultural parlance it retains a good deal of this latitude. The wild elephant which breaks into the banana patch at night or, as was found in the Coimbatore efforts to cross the sugar cane and bamboo, destroys the sugar cane mother parent, is equally and aptly a pest. The wild pig rootling in the cane field, or within personal experience, ploughing up the golf greens and crunching up the tin lining of the hole, is undoubtedly a pest. The rat passim is no less obnoxious and, as far as agriculture is concerned, its control usually falls to the lot of the entomologist as, in the Sudan, did the control of the migratory sparrow. Thus, by stages, is reached the narrow definition of a pest, that in which the word is used in the recent case: noxious animals belonging to the Order of Insecta. The resistance here under discussion is a capacity inherent in the plant which enables it to withstand the attacks of the pest and it is difficult to conceive, at least in agricultural plants, any character which would render it resistant to the wild elephant; though, even here, it is not possible to draw a sharp line. The writer has experience

* *International Sugar Journal*, Vol. 44, No. 527, 1943.

† *Bot. Rev.*, 1941, 7, p. 543.

of one Agave (Sisal) plantation which failed to become established owing to the ravages of wild pig. The actual remedy was a gun but it is conceivable that a form of Agave with strong marginal spines to the leaves might have been effectively resistant. The resistance referred to, thus, includes only those characteristics of the plant which enable the plant to avoid, tolerate or recover from the attacks of insects under conditions which would cause greater injury to other plants of the same species, lacking those characteristics.

The study of resistance in plants to insect attack is comparatively modern, though the fact of such resistance in particular cases had long been noted, the earliest being that of Underhill wheat to the Hessian fly, recorded in 1792. Between that date and 1920 only 37 records have been traced. The latter stimulation of interest is founded on the hope of obtaining, by breeding and other means, from the existing varieties, forms which, while retaining the valuable characteristics, also possess an adequate degree of immunity. For nature is a perverse damsel and rarely provides all the characters desired by man in a single form. This hope received encouragement from corresponding success attained in the case of disease. In many plants resistance to diseases was found to be a simple plant character responding to the simplest of the laws of inheritance. A form of cotton resistant to the cotton wilt was obtained in one step and the writer similarly obtained a form of pigeon pea (*Cajanus indicus*) fully resistant to wilt by the simple process of selecting and growing as single plant cultures the few remaining plants in a crop almost completely destroyed by wilt. In such simple cases it has not been necessary to trace the nature of the resistance, the character in the plant to the possession of which its immunity is due; but, in general, such a knowledge would be useful. So long as exposure to infection remains the sole test of resistance the presence of the attacking organism is necessary to the selective process. The incidence of both pests and disease is fickle and it is not possible to guarantee an outbreak of adequate intensity at the time and place of the trial. Moreover, it may be desired to raise varieties in a locality in which the particular disease or pest, to which resistance is required, does not occur. Such is the case in Barbados where the efforts to raise varieties of cane resistant to the strains of mosaic prevalent in Jamaica are handicapped by the absence of those strains. Such, too, is the case in Hawaii where, as a precautionary measure, it is desired to know the reaction of their new varieties of cane to diseases as yet not present but liable to be introduced.

It is unfortunate that this association of resistance with a recognizable plant character is rarely possible. In the case of pests, it is probable that, in most cases, no single character is responsible. Classification, therefore, becomes difficult but may be broadly made under the heads, physical, such as hardness making puncturing difficult; chemical, as the presence of some unpalatable substance in the sap, or physiological such as period of maturity causing a time break in the incidence of susceptible plant stage and insect development. Among the many examples given, several are drawn from the sugar cane.

In Puerto Rico (1) it has been suggested that late maturing varieties are less susceptible to attack by moth borer (*Diatraea saccharalis*) while, in Queensland, (2) the same has been found to hold good in the case of the grub *Lepidoderma albohirtum*. Unattractiveness or repellence for oviposition has been suggested as a cause for relative immunity (3).

Perhaps the best association yet found between a plant character and the various boring insects is, however, hardness of the stem. As early as 1929 E. H. Hazelhoff (4) had found a direct relation between whitetop borer (*Scirpophaga intacta*) infestation and hardness of the leaf spindle. Hardness is here defined as the dry substance ratio of the spindle, and the inverse correlation found between this and the intensity of infestation was a varietal character. R. W. E. Tucker (5) used the same method of determination of hardness to demonstrate a similar inverse correlation between varietal hardness and infestation by the borer *Diatraea*. Though the correlation was not very close, the new variety, B.891, introduced for its resistance to gumming disease, was found to be more subject to attack than B.11569 and the "softest" of all the varieties tested. Hardness, as used here, might better be defined as toughness of tissues for, as measured, it is an indication of fibre content. Consequently, it explains the direct correlation found by L. D. Cleare (6) between borer damage and sucrose content. The term "hardness" might, perhaps, with benefit be limited to that other character which has been identified with degree of infestation by borers of more than one species, rind hardness. F. X. Williams (7), in Hawaii, found rind hardness to be a deterrent in the case of the borer *Rhabdocnemis obscura*. In Hawaii hardness is determined by an instrument by which the degree of hardness is measured as the force required for the penetration of a needle. The same method has been adopted in Queensland in the case of the same borer (8). J. H. Buzacott has given a description of the instrument used together with determinations of a large number of varieties. Comparable figures for different varieties are, however, difficult to secure for the

(1) *J. Dept. Agric. Porto Rico*, 1922, 6, p. 21.
(2) *Rept. Bureau Expt. Sta.* 1934, 34, p. 50.
(3) *Sugar Bull.*, 1935, XIII, 11, p. 3 and *J. Dept. Sci. Barbados*, 1933, 2, p. 53.
(4) I. S. J., 1932, p. 378.
(5) *Agr. J. Barbados*, 1933, 2, p. 53 and 1936, 5, p. 121.
(6) *Trop. Agriculture*, 1932, 9, p. 264.
(7) *Rep. Exp. Sta. Hawaii Sugar Pl. Assn.*, 1935, p. 20.
(8) *Proc. Queensland Soc. Sugar Cane Technologists*, 8th Conf., 1937, p. 143.

hardness, though in its relative sense characteristic of a varietal difference, is subject to, and responds to many external factors. Thus age, lodging, trashing and growth under abnormal conditions all influence the hardness of the stalk while a considerable variation in the degree of hardness is found not only at different heights of the stalk but even at different points of each node. On the figures obtained after taking into account all these possibilities of variation, Q2, a variety accepted as resistant on the basis of borer counts, has also the highest figure for rind hardness, while SJ 4, HQ 409, B 147 and D 1135, recorded as moderately susceptible varieties have a medium rind hardness.

C. L. Withycombe, (9) in a very detailed account of the sugar cane froghopper, found an association between intensity of attack and the water content of the tissues with resistance possibly due to incompatible food relations. A. F. Bell (10) traced the apparent resistance of SJ 4 to *Lepidoderma albohirtum* in Queensland, not to an inherent capacity to resist attack but to a capacity to recover rapidly after attack through the rapid regeneration of the root system.

There is little in the above to indicate any clearly defined character or characters associated with resistance to insect attack in such a way as to simplify the breeding problem, though there are indications that resistance is in some degree inherited. Thus W. F. Jepson and H. Evans (11), in Mauritius obtained M 104/30 from the cross Uba × POJ 2878, the former resistant and the latter susceptible to attack by *Phytalus* R. Mathes *et al.* (12) have reported on a number of crosses in respect to their resistance to borer (*Diatraea*). Only three of the 27 crosses were found to yield progeny significantly less bored than the average, the most resistant being Co 281, NG 251, and it appeared that resistance was derived from the NG parent. No definite association between resistance and any plant character was found.

It is pointed out, in conclusion, that the possibility of breeding varieties resistant to insect attack successfully is not merely a question of the plant. The insect is also an organism and subject to variation. Within the species strains, or biological races as they are sometimes called, are known to exist and the possibility of the development of new races cannot be overlooked. Resistance to one race of a particular insect does not necessarily imply resistance to another. There is, thus, no certainty that a resistant variety will retain its capacity to resist indefinitely. This phenomenon is, again, more clearly evidenced in the case of disease. The existence of several strains of mosaic on the sugar cane is now a well established fact and the problems it raises for the breeder are well illustrated in the work of the Central Sugar Station in Barbados. The present review does not cover this aspect.

H.M.L.

(9) *Ann. App. Biol.*, 1926, 13, p. 64.
(10) *Cane Growers' Quarterly Bull.*, 1934, 2, p. 9.
(11) *Rev. Agric. Maurice*, 1935, 81, p. 97.
(12) *Int. Soc. Sugar Cane Tech., Proc.*, 1939, 6, p. 581.

THE BLANCHING OF VEGETABLES

Researches in recent years have shown that canned foods are fully equal in nutritive value to similar foods cooked in the home, but the maintenance of high standards of nutritive value calls for a thorough knowledge of the various processes used and the exercise of adequate control in the factory. A case in point is the "blanching" of vegetables a process which has been recently studied at the Campden Research Station of the University of Bristol.

Vegetables, before they are filled into cans, are scalded for a few minutes in boiling water or steam. This process has been used for many years and was first recommended on the grounds that it improved the flavour of the vegetables and caused the tissues to shrink. Losses of nutritive substances were known to occur, but the extent of these losses had not been fully investigated until the needs of the present time called for a closer study of the problem. Recent work at Campden has shown that blanching in hot water or steam produces certain very advantageous results—notably a sudden shrinkage in volume of the vegetables which enables a greater weight to be filled into the cans. Vegetables gain in weight during the subsequent process of sterilization, but the increase is much greater in blanched than unblanched vegetables. The combined effect of these two actions is to save 10 to 15 per cent. of volume in producing a given drained weight of the canned vegetables, and this represents not only a large reduction in transport space but also a very considerable saving in tinplate. This action, which is generally complete within two or three minutes, would alone justify the use of a blanching process, but certain other advantageous physical changes of a minor character have also been shown to occur. Blanching in water or steam does not alter the colour of vegetables appreciably, but in some cases it improves the flavour.

On the debit side of the account must be placed the losses in nutritive materials. These occur very largely during the first two or three minutes of the blanching and are greater in water than in steam. The extent of these losses depends on the shape, size, and texture of vegetables, the smaller units of large surface area in proportion to their volume losing nutritive material more rapidly than the larger units. It has been found that the losses of sugars, proteins, mineral substances and vitamin C in an efficiently controlled blanching process need not be high, and it is recommended that the time of blanching should depend on the physical state of the vegetables. It is fortunate that shrinkage generally takes place rapidly, and in such cases the blanching time can be very short, with consequent saving of valuable nutritive substances.—(*Monthly Science News*, No. 16, 1942.)

CHEMICAL NOTES

(Compiled by the College Department of Chemistry and Soil Science)

Evaluation of Sugar Cane Manurial Trials by Foliar Diagnosis Methods

According to the twelfth Annual Report of the Sugar Cane Research Station, Mauritius, analyses of leaf samples from manurial trials of sugar cane consisting of the third fully expanded leaf from the top in climatic conditions suitable for optimal growth, continue to show that in so far as phosphates and potash are concerned the method of foliar diagnosis is reliable. A set of analyses of cane leaves from different climatic zones of the island and from different sizes of holdings has shown that the type of holding has been important in deciding whether the canes obtain sufficient P or K, the climatic conditions being relatively unimportant.

Use of leaf and stem injection methods for the diagnosis of nutrient deficiency in sugar cane is not considered promising. Better results have been obtained from a growth rate method developed from data of the growth of fertilized and unfertilized plants and from uniformity trials. Two facts were established : (1) that large growth responses to fertilizer were obtained only during the season when growth was active in presence of ample moisture and high temperatures ; observation should therefore be confined in general (in Mauritius) to the period mid-December-mid-April ; (2) variability in the absolute growth rate of stools was so high that measurement offered great difficulty. There was, however, a very close relationship between the growth made by any one stool in a period of, say, one month, and the growth made by the same stool in a later month. The method is based on these facts, and the technique of treating results is exemplified in the Report. The method has been shown to have considerable value since the increased growth increments resulting from fertilizer treatments are the direct forerunners of increased yields. The fact that positive results are obtained in a period of two months makes it possible to apply the results to benefit the current crop ; the method also has the advantage of being within the capacity of practical agriculturists.—(*Soils and Fertilizers*, V, No. 5, 1942.)

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Copper Deficiency in Plants

C. S. Piper in a paper published in *J. Agr. Sci.*, XXXII, pp. 143–178, confirms the essential nature of copper for plant growth and describes a water-culture technique which makes it possible to determine with precision the effects on plant growth resulting from the absence of traces of heavy metals. Characteristic signs produced by growing several crop plants in solutions devoid of copper are described ; the stage of development at which copper becomes requisite and the range of concentrations of copper for optimal growth are discussed. The copper contents of normal and copper-deficient oat plants at various stages of growth are recorded. The degree of moisture saturation of soil had little effect on the copper uptake of plants. An increase of soil acidity to pH 4.7 increased the availability somewhat, while partial sterilization by heat had a greater effect. In neither case was the increase of the same order of magnitude as with manganese. The increased absorption of copper by plants as the result of applications of copper sulphate to the soil was very small. Rye can grow normally on soils on which oats fail from marginal copper deficiency.

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Ground Limestone and Soil Fertilizers

It has been found in Illinois that the most economical grinding of limestone is probably that which provides a gradation of sizes finer than 6-mesh. A small amount of coarser material up to 4-mesh (1/5 inch), is permissible, although the action of such coarse material is very slow. It was found to take about a year or eighteen months for soil to have its acidity reduced appreciably throughout a range of about half an inch from a fixed mass of limestone. In pasture experiments limestone was the most effective single agent in increasing the total growth of forage over the whole grazing season, a combination of limestone and phosphate being more effective than was either material alone.—(*Soils and Fertilizers*, Vol. V, No. 5, 1942.)

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Pectin from Tamarind Seeds

Pectin is an everyday article of food, and makes its appearance in jams, cold jellies, eandies and confectionery. Most of it is prepared from the waste products of fruit juice industries such as apple pomace, lemon and orange pulp, &c. Pectin finds extensive application in other industries also. As a filler in soap it not only increases the yield but also adds to its detergent properties. It is used in thickening rubber latex, as an emulsifier in cosmetics, and the metal salts find application as bactericides and as water repellents. The hitherto common sources of pectin are all easily perishable and the pectin industry had to be coupled on to the primary industries of fruit juice expression, &c. A recent examination of various seeds (*Indian Forest Leaflet*, No. 23, 1942, by T. R. Ghosh and S. Krishna) has led to the discovery of a rich source of pectin in the tamarind seeds available in India in considerable quantities as waste product. The seed kernels contain 60 per cent. pectin (alcohol precipitation) and a process for its isolation is detailed.—(*Current Science*, Vol. XI, No. 9, 1942).